The first National Scientific User Facility experiment is now being irradiated in INL's Advanced Test Reactor.

INL kicks off first university experiment in Advanced Test Reactor

by Roberta Kwok, *Research Communications Fellow*

A pilot project testing candidate materials for the next generation of nuclear reactors fired up Sept. 23 at Idaho National Laboratory.

A collaboration with the University of Wisconsin-Madison, this experiment is the first in a series of partnerships between INL's Advanced Test Reactor National Scientific User Facility and academic researchers across the country. With more than 500 samples, the pilot study will test materials ranging from nanoparticle-enhanced alloys to "amorphous" metals whose chaotic atomic structures are thought to resist corrosion. The ATR will irradiate the samples with neutrons for two years, replicating the high-temperature, radioactive beating they would take in an advanced nuclear power reactor.

Such experiments are essential to design advanced power reactors, meant to run longer and at higher temperatures, says INL engineer Heather MacLean, who led the experimental design. The results could apply to future light water reactors, fast reactors, and gas cooled reactors such as the one planned for INL's Next Generation Nuclear Plant. "There are many varieties of advanced reactors being proposed, but all of them require advanced materials, not just new types of fuels," MacLean says.

Nuclear power reactors generate electricity by using heat from the fission of uranium fuel to evaporate water into steam and power a turbine. In addition to creating heat, the fission process also releases neutron radiation. The radiation can gradually degrade materials used in the protective fuel cladding and the reactor's core vessel, where the fission takes place. Cracks can form along the grains of the material, or the absorption of neutrons may cause swelling.

INL engineer Heather MacLean, who helped design the experiment, and Michael David watch on a video screen as the experiment is loaded into the ATR.

The Advanced Test Reactor allows scientists to find out which materials can withstand such an extreme environment. Researchers can insert samples into the ATR and pelt the material with neutrons to simulate the radiation in a nuclear power reactor. In 2007, INL opened the reactor to the academic community by establishing the ATR National Scientific User Facility.

A UW-Madison team wanted to test a suite of structural materials that might be resistant to high temperatures and radiation. "We're looking at different materials and treatments that have never been exposed to neutron irradiation before," says principal investigator Kumar Sridharan, whose project proposal was accepted in December 2007.

One type of material, called nanophase alloys, contains nanoparticles that act as reinforcements and prevent the alloy from deforming. Such alloys are known to withstand high temperatures, but no one has yet tested the effect of radiation. Neutrons could potentially split the nanoparticles, Sridharan says, and the ATR experiment will reveal whether the alloys remain stable in a nuclear reactor environment.

One type of sample, which measures about three millimeters across, will be examined under an electron microscope for signs of damage.

The Wisconsin team also fabricated materials called "amorphous" or "glassy" metals. These are created by cooling liquid metals very quickly, causing the atoms to settle together haphazardly rather than in an orderly crystalline pattern. Their unusual structure makes the metals more resistant to corrosion, and Sridharan wants to find out whether the materials slip back into crystal form when exposed to radiation. The team's samples also include metals with high melting points, like tungsten, and materials that have been engineered to withstand cracking.

But getting the samples into the Advanced Test Reactor was no easy task. MacLean and INL engineers Jim Parry and Paul Murray had to design the arrangement of more than 500 samples in 12 small rods, or "rodlets," so that each sample would be exposed to the right temperature and radiation levels. For example, the team had to concoct different mixtures of helium and argon gas for each rodlet to adjust the amount of heat that would stay inside.

The intense preparation needed for ATR experiments sets it apart from other types of user facilities such as beamlines, MacLean says. "At a lot of other user facilities, you're talking about experiments that take days, maybe a week or two," she says. "With a reactor, you can't just throw stuff in."

After being bombarded with neutron radiation for one to two years, the rodlets will be removed for materials testing. The researchers will examine one set of samples -- shaped like thin discs about three millimeters across -- under electron microscopes to look for changes such as tiny nanoscale holes or separation of alloy elements. Other samples -- resembling miniature dog bones -- will undergo mechanical testing to see how much force it takes to snap the material in half. By comparing the results to those of unirradiated samples, the researchers can gauge whether radiation has changed the strength of the materials.

The Wisconsin experiment is just the first in a series of collaborations with universities. Researchers from the University of Florida, University of Illinois, North Carolina State University, and University of California-Santa Barbara -- whose projects were selected earlier this year -- will also run experiments in the ATR User Facility.

INL project manager Julie Foster says the team will use lessons from the current pilot study to reduce the time and cost of preparation for the next round. "To solve the world's energy crisis between a national lab and the universities -- that concept is very important," Foster says. "The fact that we've made it on schedule is a huge success."

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